Release Notes* for
AIRS Science Processing Software
V3.0.10.0

In response to unusually intense solar activity during late October and early November 2003, the AIRS suite of instruments (AIRS, AMSU-A1 and AMSU-A2) on Aqua were powered off as a preventative safety measure on October 29, 2003 at 02:00 UT. The spacecraft and the AIRS suite of instruments weathered the solar storm were reactivated once solar energy returned to normal levels. While the AIRS Project understands the need for a continuous uninterrupted data stream, it was felt that it was imperative to protect the health of these instruments. Data collection for AMSU-A was resumed on November 4, 2003 at 5:59 UT. Data collection for AIRS was resumed on November 19, 2003 at 06:18 UT. Slight changes in channel responses for the AIRS instrument necessitated release of V3.0.10.0, a newer version of AIRS/AMSU-A Science Processing System software. No other changes were included in this release.

A detailed description of the impact of the solar event on the AIRS suite of instruments, the AIRS Project Team response to that event, and assessment of V3.0.10.0 is provided in this document.

*Note: As V3.0.10.0 does not constitute a significant change in the AIRS Science Processing System, a comprehensive release document and validation report was not produced. The behavior of the AIRS suite of instruments and the AIRS Science Processing System remain largely unchanged from pre-solar event conditions. For, more detailed description of AIRS Science Software and validation activities, please refer to the following documents:

V3.0 User's Guide: AIRS Version 3.0 L2 Release Documentation
Validation Report: Validation Report of AIRS Core Product V3.0

A complete set of AIRS documents can be found at the AIRS Data Support Documentation

Timeline of Events

In late October and early November of 2003 there was a period of unusually intense solar activity. Some solar flares and coronal mass ejections were among the highest ever recorded. The AIRS Project decided to turn off AIRS and AMSU-A to ensure instrument safety during these storms. While the importance of maintaining an uninterrupted data stream is well understood, the intensity of these solar storms necessitated this action. The AMSU-A and especially the AIRS instruments contain sensitive electronic components that might be permanently damaged if hit with a sufficiently high-energy proton while powered on. Permanent instrument failures were possible. However, while powered off, these instruments would NOT be damaged if hit by the same particles. Thus, a decision was made to power down both instruments.

Power Down Sequence. AIRS and AMSU-A were powered off a little after 02:00 UT on October 29 2003 (about 9:00 p.m. EDT October 28, 2003). The detailed timeline for power down is provided below:

02:15:40 AMSU-A1 scanners parked at warm target
02:19:07 AMSU-A1 completely powered off
02:22:29 AMSU-A2 scanner parked at warm target
02:26:08 AMSU-A2 completely powered off
02:30:00 AIRS shutdown macro begins execution – *AIRS science data no longer valid*
04:31:50 AIRS completely powered off

Power Up Sequence. The process of bringing AIRS and AMSU-A back to operability began on November 3, 2003, once the solar storm ended. Activation of AIRS is a very lengthy process and was not completed until November 6, 2003. As the AIRS instrument is very sensitive to power off/on cycles, once AIRS was activated, a series of calibration tests adjustments were performed. These lasted until November 19, 2003, when the AIRS instrument was placed back into "Operate" mode. The AMSU-A instrument does not require recalibration, and was brought back into service several days earlier. A detailed power on timeline is provided below:

November 3, 2003 – All three AIRS suite instruments, AIRS, AMSU-A1, and AMSU-A2 were powered on. AMSU-A begins scanning, but is using the default (non-optimal) space view #1. Many temperatures are below normal operating limits. Consequently, the science data are not of the highest quality.

November 4, 2003 – AMSU-A1 completed warm up and it was switched to the optimal space view (space view #3) at 15:59 UT. AMSU-A2 completed warm up and it was switched to the space view #3 at 18:19 UT

November 6, 2003 – AIRS became fully operational at 18:30:25 UT, but recalibrations and some reconfiguration were still needed. Science quality data are **not** being produced.

November 6, 7, 8, and 9, 2003 – Daily guard tests run for the AIRS instrument.

November 7, 2003 – Three space view noise tests run for the AIRS instrument.

November 14, 2003 – Based on analysis of calibration tests and normal science data, the set point for the second stage radiator temperature was changed from 155.00 K to 155.56 K. The command was issued at 21:02 UT. This changes the temperature of the AIRS optics. The purpose was to make detector frequencies match their values prior to the shut down. This still leaves some residual radiance differences because the phase of the channel spectra is also temperature-dependent. This effect will be accounted for when the next version of the rapid transmission algorithm becomes operational. (Prior to the temperature change a guard test was run.)

November 16, 17, and 18, 2003 – Daily guard tests were performed to confirm that the temperature change had the desired results.

November 18, 2003 – A new detector gain table was uploaded to the spacecraft buffer awaiting transfer to AIRS.

November 19, 2003 Final guard test run to transfer new gain table to AIRS and verify it. At 06:18:00 AIRS returned to OPERATE mode using the new gain table.

AIRS Recalibration and Level 1B Software Update

As stated previously, the AIRS instrument is very sensitive to temperature fluctuation associated with power down and up cycles. The complex interaction between sensor electronics and AIRS optics temperatures requires intensive calibration studies to be undertaken with each new power up activity. (The AMSU-A instruments are not as temperature sensitive, and do not require recalibration.) Once recalibrated, The AIRS Level 1B Product Generation Executive (PGE) also had to be upgraded to reflect calibration table changes.

V3.0.10.0 is identical to the previous release of AIRS science software (V3.0.8.0) in all respects except for the Level 1B AIRS PGE which was modified to account for changes to the instrument following the October, 2003 solar flare shutdown. V3.0.10.0 changes consist entirely of a new Channel Properties File, and no changes to any algorithms were made. Since the new channel properties file isn't used for epochs before November 19, 2003, there is no impact to data collected prior to that date. Post November 19th, effects can be broken into two categories: changes that are accounted for by the Channel Properties File, and instrument changes not represented by the Channel Properties File. These changes are described below:

Changes were made to the *ABState* and noise (*NEdT*) estimates field of the Channel Properties File. Overall, channel properties for most channels remained unchanged (Table 1). In addition, changes were propagated through to the *rad_qual* and *bad_flag* fields. No other fields were changed. These new values represent the best understanding of how the instrument is performing following November 19, 2003.

Table 1. Summary of ABState Changes After Latest Thermal Cycle.

State Change Condition	**Number of Channels**
State change from *good* (ABState < 3) to *bad* (ABState ≥ 3)	68
State change from *bad* (ABState < 3) to *good* (ABState ≥ 3)	42
State changed, but remained *good* (ABState < 3)	180
State changed, but remained *bad* (ABState ≥ 3)	66
Total Number of Channels with different ABStates	356
Total Number of Channels with the same ABStates	2022
TOTAL Number of Channels	2378

The changes not accounted for by the Channel Properties File are due to changes in the instrument thermal environment. Specifically, the Spectral Response Function (SRF) of each

detector is temperature-dependent. SRF centroids were found to have shifted after the instrument was turned back on. Taking advantage of the temperature-dependent SRFs, the optical bench temperature was increased by 0.56K, which had the effect of returning the SRF centroids to their pre-solar flare values. Thus the channel frequency centroids reported in the new Channel Properties File are identical to those in the old file.

The one undesirable effect of restoring the centroid frequencies to their original values by changing the optical bench temperature was that entrance filter temperatures were changed as well, slightly changing the phase of the channel spectra they induce on the detector SRFs. Thus the Level-1B radiances remain untainted, but their scientific interpretation changes slightly.

The differences in observed brightness temperature with and without channel spectra have a mean of 0.03 Kelvin, a standard deviation of 0.06 Kelvin, and a maximum of 0.5 Kelvin. The differences due to the change in channel spectra phase have yet to be investigated, but are likely an order of magnitude smaller than this. The new (post-November 19, 2003) SRFs will be incorporated into the Radiative Transfer Algorithm (RTA) to be included as part of a future delivery of AIRS Science Processing Software.

Effects on the Level 2 PGE

Several days of data were processed using V3.0.10.0 to confirm qualitatively that the Channel Properties File update (for data collected on and after November 19, 2003) did not have any unintended effects on the Level 2 retrievals. Specifically, two data days occurring before November 19, 2003 (09/06/2002 and 10/18/2003) and one data day (12/05/2003) occurring after the November 19, 2003 update were processed. While changes were noted, no significant changes have been identified. Two figures are provided below that summarize our findings.

First, one indicator of retrieval quality, is the Retrieval Type. A Retrieval Type of 0 indicates a full successful retrieval, while all other retrieval types indicate special retrieval conditions. While analysis of specific retrieval types is unimportant for this comparative study, a return of similar retrieval types for each global run of the Level 2 PGE would indicate that no substantive changes occurred to the Level 2 PGE as a result of change to Level 1B. After the retrievals described above were completed, a table showing yields for various retrieval sets was produced (Table 2).

Table 2. Percentage Yield by Retrieval Type*

Data Day/ Version	Retrieval Type							Number of FOVs
	0	10	20	30	40	50	100	
09/06/2002-v3.0.8.0	76.9	1.5	9.8	7.6	0.0	0.1	4.2	146270
09/06/2002-v3.0.10.0	76.9	1.5	9.8	7.6	0.0	0.1	4.2	146270
10/18/2003-v3.0.10.0	71.5	1.3	12.7	11.6	0.0	0.0	2.9	146215
12/05/2003-v3.0.10.0	74.2	1.5	11.4	10.8	0.0	0.0	2.2	146086

* Total yield in percent by retrieval type for all observations between plus and minus 40° latitude over water.

The first two rows in Table 1 demonstrate that there are no differences in retrieval type statistics between the original V3.0.8.0 PGE and the PGE updated to V3.0.10.0 using identical AIRS data acquired well before the solar event. The yield for each retrieval type is identical for the two versions.

The third and fourth row of Table 1 use AIRS data sets acquired just before the solar event and after the instrument was stabilized following shutdown/recovery to demonstrate that there are no significant differences in retrieval type statistics due to instrument changes originating from the solar event or subsequent shutdown/recovery.

We have also compared the global statistics of the agreement between our retrieved air temperature profiles and their associated ECMWF forecasts before and after the solar event and instrument shutdown/recovery. Figure 1 shows the bias (dashed lines) and RMS (solid lines) of the differences between our retrieved temperature profiles and the ECMWF forecast profiles. The black profiles result from V3.0.8.0 retrievals for data well before the solar event. The red profiles result from V3.0.10.0 retrievals for data after instrument was stabilized following shutdown/recovery. The figure demonstrates that the global statistics of the bias and RMS of the retrieved temperature profiles are unchanged.

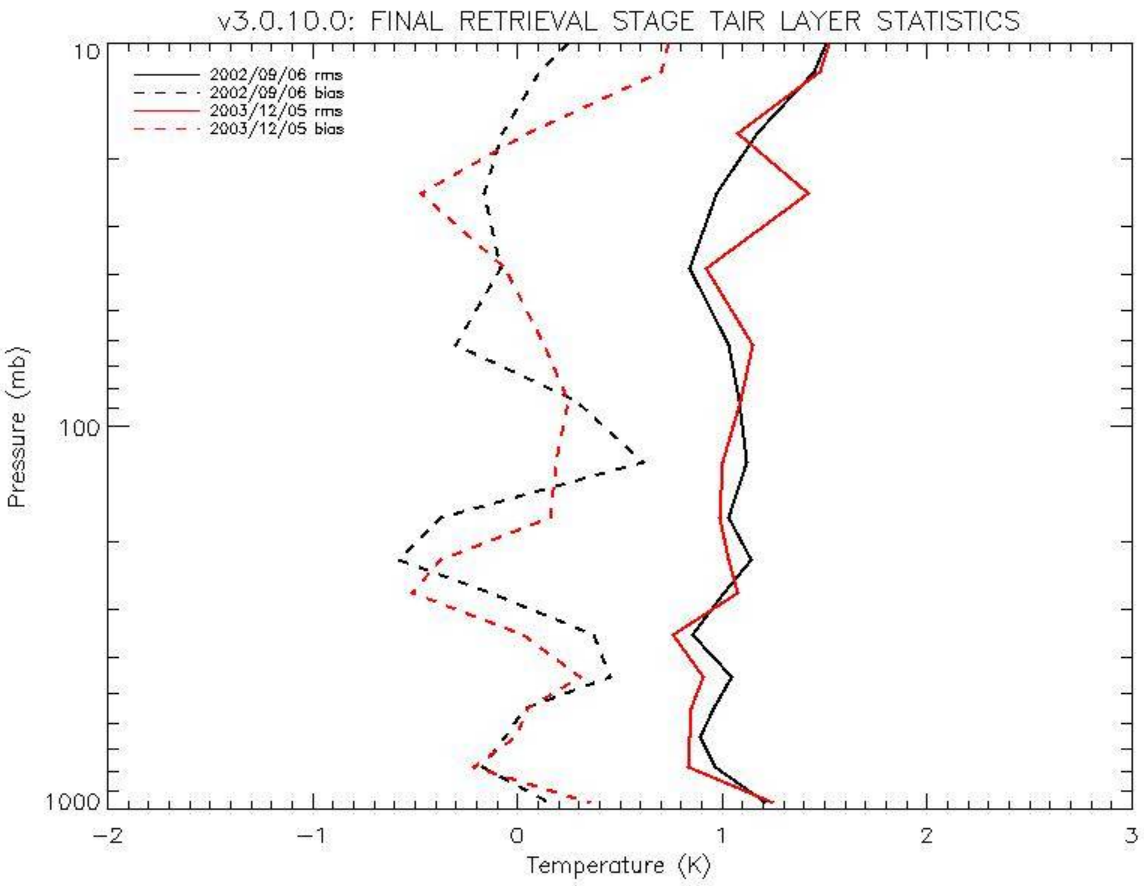

Figure 1. Final Retrieved Temperature Bias and RMS with respect to ECMWF forecast for September 6, 2002 and December 5, 2003.

As shown in Figure 1, the final retrieved temperature bias and RMS with respect to ECMWF for ocean fields of view between plus and minus 40° latitude show no significant difference. The figure also demonstrates that the bias and RMS are similar beforehand after the channel properties file update.

Planned Upgrades to AIRS Science Processing System

The AIRS Project strives to avoid instrument shutdowns, and changes in data baselines between major annually scheduled software releases. Still, situations such as the recent solar flare can occur, necessitating changes to data baselines. In addition, data losses are undesirable, but are unavoidable in such cases. The AIRS Project apologizes, in advance, if the data lapse and change in software baseline causes any confusion.

The next release of AIRS Science Software, V4.0, is planned to occur late in calendar year 2004. While improvements to all existing PGEs are expected, major emphasis will be placed in releasing a Level 2 PGE that provides accurate atmospheric temperature, moisture, and trace gasses over land areas as well as water and into the middle and higher latitude zones. In addition, V4.0 is planned to include three new Level 3 products. No interim releases are anticipated

between the release of V3.0.10.0 and V4.0. However, if a similar condition to the one experienced in late October 2003 occurs again, another interim release may be needed. Again, none are anticipated at this time.